using a monotonically variable angular velocity of the spool to control the stress state in the buffer tubes and subsequently the EFL.

Experiments were focused on a three-step angular velocity process. The first step is an initial stage of the reeling process when angular velocity is increased from zero to a prescribed value. The second step is ramping or transition in angular velocity from 100 m/min to 400 m/min. The third step is a non-ramping scenario to the end of the reeling process, when the angular velocity is kept constant. These stages of the reeling process are depicted in Figure 36, where the angular velocity, ω, is related to the linear velocity, v, of the buffer tube and current radius, r, as shown below:

Results of several experiments (Exp. 14, Exp. 15 and Exp. 16) are summarized in Figure 37, which shows EFL distribution as a function of length of the buffer tube. In all three cases shown, a thin soft pad on the reel core and decaying take-up tension were used. These results suggested the influence of the variable angular velocity on the EFL curves. Curve 14 is obtained at a relatively high constant linear speed of 400 m/min. As previously discussed, a high level of line speed reduces cooling time for the buffer tubes and reduces the time-to-stretch (creep, reduction in the Young's modulus), and consequently, produces relatively high levels of EFL.

Also, a transition from lower to higher line speed increases the cooling time for the initial part of buffer tubes, increases the time-to-stretch (creep, reduction in the Young's modulus), and consequently, reduces levels of EFL at the beginning of the buffer tube. Further, a dynamic transition from lower to higher speed adds inertia forces of tension and thus increases stretching of thermoplastic material and reduces EFL in the initial part of buffer tube length. Curve 15 is obtained via ramping when the linear velocity was

monotonically increased (as a linear function) from an initial value of 100 m/min to 400 m/min, and achieved its maximum of 400 m/min when the tube length was about 1.5 km (dashed line in Figure 37).

Constant lower line speed uniformly increases the cooling time, increases the time-to-stretch, and consequently, uniformly reduces levels of EFL. Curve 16 is obtained at a constant line speed of 100 m/min.

To further analyze one embodiment of the present invention, further analysis using thin foam pads on reels and monotonically decaying the take-up tension was investigated. For this purpose, a system based on a bucket of water and a valve was built and successfully used. It was found that this system provided results with good repeatability. The valve was used to accelerate water release to provide a parabolic decay in the tension. Friction of the bucket against a pole additionally provided a favorable reduction in the vibration of the load and presumably, smoother EFL curves.

Figure 38 shows a modified line according to the present invention that employed a bucket of water to control take-up tension in the form of a parabolically decaying function. Figure 39 depicts the EFL curves for two experiments using the tension control. The case corresponding to curve Exp. 27 was performed with the following sequence of take-up load: start with 30N, after the first 4000m the load is 27N, after 8500m the load is 20N, then it decreases monotonically down to 12N. One thin layer of foam was wrapped around a regular steel core, and the line speed was kept constant at 400 m/min. Curve Exp. 31 represents another scenario: one thin layer of foam wrapped around a regular steel core, with an initial line speed of 350 m/min, and a take-up tension of 30 N. After 9 km of buffer tube was made, the flow rate of water was increased.

The main result of the experiments involving a bucket of water with a valve is controllability of the EFL using soft foam pads and decaying take-up tension. Based on the experiments, it is recommended that a pneumatic-controlled system for more accurate computer-controlled take-up tension is to be used to obtain a constant-value EFL, although any system capable of provide the control needed can be used.

In reviewing the above analysis and experimentation a number of embodiments of the present invention are contemplated, where various aspects of the buffer tube manufacturing process are used individually, or in combination, to achieve a buffer tube or cable having a substantially even EFL distribution along its length.

In a first embodiment of the present invention, the take-up tension of the buffer tube is monotonically decayed as the tube is wound on the reel. The exact function used to decay the tension would be governed by the individual characteristics of the manufacturing system to be used, but is to be optimized by taking into account all of the factors previously discussed, including, line speed, reel core diameter, material properties, etc. Although it is preferred that a monotonically decaying function be used, it is contemplated that other functions may also be used to decay the tensile load on the tube during manufacture, without expanding the scope or spirit of the present invention. Further, although one of the main purposes of the present invention is to create uniform EFL distribution throughout the length of a buffer tube, it is contemplated that the present invention can be used to create a controlled non-uniform EFL distribution throughout the length of the cable, where such a non-uniform distribution is desired.

In the preferred embodiment, the decaying tension is to be supplied by a pneumatic-controlled system for more accurate computer-controlled take-up tension and to obtain a